

# **Diesel Fuel Comparison Study Workshop**

**December 3, 2008**

**California Environmental Protection Agency**

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**Air Resources Board**

# Agenda

- Project Overview
  - Project Schedule
  - Staff Recommendation: Diesel Test Fuel Properties
    - CARB ULSD
    - Federal A ULSD
    - Federal B ULSD
  - Staff Recommendation: Revised Test Plan
    - Objective & Scope
    - Proposed Test Engine/Cycle Selection
    - Proposed Test Vehicle/Cycle Selection
- Future Discussion Topics
- Next Meeting

# **Project Schedule**

- Contract reinstated on November 3, 2008
- Auto Alliance 2007 Summer Diesel Fuel Survey purchased
- Advisory panel convened December 3, 2008
- Review of fuel properties complete
- Need to purchase and ship diesel test fuel
- Need to finalize draft test plan
- Emissions Testing – scheduled to begin in March 2009
  - Coordinating schedules with Biodiesel Research Program

# Diesel Test Fuel Selection

- Staff Recommendation - Propose using three test fuels:
  - Representative or 'Average' CARB ULSD
  - Representative or 'Average' Federal ULSD
  - Commercially available Federal ULSD with fuel properties that would lead to higher exhaust emissions

# CARB Diesel Fuel Properties

Summer 2006 & 2007 averages and Proposed Test Fuel Ranges

Property	Average Fuel Properties <sup>1</sup> Summer 2006 <sup>2</sup>	Average Fuel Properties <sup>3</sup> Summer 2007 <sup>4</sup>	Proposed Ranges for “Average” CARB ULSD Test Fuel
API Gravity	38.5	37.6	37.5 – 39
T50 (°F)	479	480	470 – 490
T90 (°F)	606	602	595 - 615
Aromatics (V %)	17.6	16.7	16 – 18
Cetane Number (additized)	51.3	51.8	51- 54
Sulfur (ppm)	4.4	4	<5

<sup>1</sup> All data represent volume weighted averages.

<sup>2</sup> Summer 2006: Refers to the period from June 1 through September 20, 2006.

<sup>3</sup> Data average of 12 - 50 samples taken from CA refineries, volume weighted.

<sup>4</sup> Summer 2007: Refers to the period from May 21 through August 16, 2007.

# Federal Diesel Fuel Properties

**“Alliance of Automobile Manufacturers” North American Fuel Survey”**

**Summary Statistics for Selected Properties from the Summer 2007 Survey**

**Note: Statistics based on data from 17 U.S. cities, Los Angeles data has been removed**

#2 Regular Diesel S15	2007 Summer <sup>1</sup>		
	min	max	avg
Gravity, °API	33.0	38.9	35.5
T50 (°F)	472	548	506
T90 (°F)	576	639	607
Aromatics (V %)	19.9	40	28.2
Cetane Number	40.2	55.0	46.4
Sulfur <sup>2</sup> (ppm)	2	17	6
<sup>1</sup> Samples taken in July 2007 <sup>2</sup> Using ASTM D5453			

# Federal Diesel Fuel Properties

Northrop Grumman 2007 Diesel Fuel Oils Survey, April 2008  
2-D Low Sulfur On-Highway Fuel, Summer 2007

#2 Regular Diesel S15	2007 Summer <sup>1</sup>		
	min	max	avg
Gravity, °API	34.1	39.0	35.9
T50 (°F)	476	519	496
T90 (°F)	568	628	602
Aromatics (V %)	17.5	35.3	28.9
Cetane Number	42.0	54.4	46.5
Sulfur (ppm)	3	8	6
<sup>1</sup> Based on 17 samples only, Summer 2007			

# Comparison of Federal Diesel Fuel Survey Data

Averages Properties of Samples Collected Summer 2007

Properties	“Alliance of Automobile Manufacturers” North American Fuel Survey Averages <sup>1</sup> , Summer 2007	Northrop Grumman 2007 Diesel Fuel Oils Survey, April 2008 Averages <sup>2</sup> , Summer 2007
Gravity, °API	35.5	35.9
T50 (°F)	506	496
T90 (°F)	607	602
Aromatics (v/v)	28.2	28.9
Cetane Number	46.4	46.5
Sulfur (ppm)	6	6
<sup>1</sup> Statistics are based on data from 17 U.S cities, data from Los Angeles, California has been removed from the sample <sup>2</sup> Statistics are based on data from 17 diesel fuel oils marketed throughout the United States by 4 petroleum refining companies		



# **Proposed Ranges for Average Federal ULSD Test Fuel Selection (Federal – A) Revised November 2008**

<b>Property</b>	<b>“Average” Federal ULSD Ranges (Federal – A)</b>	<b>“Average” CARB ULSD Ranges</b>
<b>API Gravity</b>	<b>35 - 36</b>	<b>38 – 39</b>
<b>T50 (°F)</b>	<b>490 – 510</b>	<b>470 – 490</b>
<b>T90 (°F)</b>	<b>595 – 615</b>	<b>595 - 615</b>
<b>Aromatics (v/v)</b>	<b>28 - 30</b>	<b>16 – 18</b>
<b>Cetane Number</b>	<b>44 - 47</b>	<b>51- 54</b>
<b>Sulfur (ppm)</b>	<b>6 - 9</b>	<b>&lt;5</b>

# **Proposed Ranges for Boundary Federal ULSD Test Fuel Selection (Federal – B)**

<b>Property</b>	<b>“Boundary” Federal ULSD Ranges (Federal – B)</b>
<b>API Gravity</b>	<b>33 - 34</b>
<b>T50 (°F)</b>	<b>≥500</b>
<b>T90 (°F)</b>	<b>&gt;620</b>
<b>Aromatics (v/v)</b>	<b>35 - 40</b>
<b>Cetane Number</b>	<b>40 - 42</b>
<b>Sulfur (ppm)</b>	<b>&lt;15</b>

# Revised Draft Test Plan Review

- *Assessment of the Emissions from the Use of California Air Resources Board Qualified Diesel Fuel in Comparison with Federal Diesel Fuels – Overview*

# **Objective & Scope**

- Design & implement test program to define the emissions benefits of CARB diesel fuel versus several different Federal diesel fuel blends
  - Proposed scope:
    - Engine dyno – Test 3 (4 if 2010 engine is available) engines, two test cycles
    - Chassis dyno – 9 test vehicles, 1 test cycle, ARB HHDDT cruise, multiple test repetitions per fuel
    - Fuels – 1 ‘representative’ CARB diesel, 2 Federal diesel ‘blends’
    - Emissions measurements – THC, CO, CO<sub>2</sub>, NO<sub>x</sub>, NO, PM

# Test Engine Selection - Engine Dynamometer Testing

- Test Engine 1 – 2006 Cummins ISM 370, 10.8 liter, EGR
  - EFN: 6CEXH0661MAT
- Test Engine 2 – 2007 DDC MBE4000, 12.8 liter
  - EFN: 7DDXH12.8DJA
  - EGR+OC+PTOX
- Test Engine 3 – 1991 DDC Series 60, 11.1 liter
  - EFN: MDD11.1FZAZ

# **Test Engine Selection - 2010 Compliant Engine**

- Still seeking a 2010 compliant engine for inclusion in the engine dynamometer test matrix
  - Must include NOx after treatment
  - A pre-production or prototype engine would be sufficient
  - Must locate and secure an engine for testing by March 2009 for inclusion in the study

# Test Cycle Selection – Engine Dynamometer

- Two test cycles selected
  - **First Cycle:** Heavy Duty Federal Test Procedure (FTP) Transient Cycle
  - **Second Cycle:** ARB Heavy Heavy-Duty Diesel Truck (HHDDT) cruise cycle
    - 2083 second cycle with 40 mph average speed
    - Translated cycle, can be used on engine or chassis dynamometers
    - Engine dyno results could be confirmed by chassis testing of in-use HDD fleet

# Proposed Test Vehicle Selection - Chassis Dynamometer Testing

- Propose testing a matrix of 9 vehicles
  - Matrix should be based on CA's in-use HD on-road fleet
  - Should incorporate a range of technologies if possible
  - Engine dynamometer test results will help shape final matrix



# Test Cycle Selection – Chassis Dynamometer

- ARB HHDDT cruise cycle selected
  - 12 test replicates per fuel type

# **Staff Recommendation: Approve the Revised Draft Test Plan**

- *Assessment of the Emissions from the Use of California Air Resources Board Qualified Diesel Fuel in Comparison with Federal Diesel Fuels – Overview*

Dr. Thomas D. Durbin  
University of California, Riverside  
CE-CERT

# Future Discussion Topics

- 2010 compliant engine for inclusion in the fuel comparison study
- Locate & purchase Comparison Study test fuels
- Revisions to the Test Plan
- Continued coordination with the Biodiesel research project

# **Next Meeting**

- Tentatively scheduled for January 2009
- Visit our web site
  - <http://www.arb.ca.gov/fuels/diesel/dieselcomp/dieselcomp.htm>

# Contact Information

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# HHD Population Data

## Calendar Year 2007

Model Year	Population		VMT		NOX		PM	
	(#)	(%)	(mi/day)	(%)	(t/d)	(%)	(t/d)	(%)
<b>2007</b>	<b>9,037</b>	<b>4.2 %</b>	<b>2,452,385</b>	<b>6.8 %</b>	<b>16.15</b>	<b>2 %</b>	<b>0.15</b>	<b>0.5 %</b>
<b>2002 - 2006</b>	<b>36,930</b>	<b>17.3 %</b>	<b>10,431,370</b>	<b>28.8 %</b>	<b>145.55</b>	<b>18.3 %</b>	<b>6.24</b>	<b>18.5 %</b>
<b>1994 - 2001</b>	<b>92,890</b>	<b>43.6 %</b>	<b>17,447,971</b>	<b>48.1 %</b>	<b>475.79</b>	<b>59.9 %</b>	<b>13.05</b>	<b>38.8 %</b>
<b>1991 - 1993</b>	<b>20,018</b>	<b>9.4 %</b>	<b>2,279,696</b>	<b>6.3 %</b>	<b>65.37</b>	<b>8.2 %</b>	<b>2.92</b>	<b>8.7 %</b>
<b>1987 - 1990</b>	<b>27,395</b>	<b>12.9 %</b>	<b>2,388,688</b>	<b>6.6 %</b>	<b>59.42</b>	<b>7.5 %</b>	<b>6.99</b>	<b>20.7 %</b>
<b>Pre - 1987</b>	<b>26,584</b>	<b>12.5 %</b>	<b>1,259,343</b>	<b>3.5 %</b>	<b>31.78</b>	<b>4 %</b>	<b>4.33</b>	<b>12.8 %</b>

# MHD Population Data

## Calendar Year 2007

Model Year	Population		VMT		NOX		PM	
	(#)	(%)	(mi/day)	(%)	(t/d)	(%)	(t/d)	(%)
<b>2007</b>	<b>11,257</b>	<b>6.1 %</b>	<b>946,742</b>	<b>8.1 %</b>	<b>3.67</b>	<b>2.6 %</b>	<b>0.10</b>	<b>2.6 %</b>
<b>2002 - 2006</b>	<b>53,112</b>	<b>29 %</b>	<b>4,335,829</b>	<b>37.2 %</b>	<b>35.34</b>	<b>24.8 %</b>	<b>0.89</b>	<b>24.1 %</b>
<b>1994 - 2001</b>	<b>75,111</b>	<b>41 %</b>	<b>4,884,153</b>	<b>41.9 %</b>	<b>71.71</b>	<b>50.3 %</b>	<b>1.56</b>	<b>42.2 %</b>
<b>1991 - 1993</b>	<b>13,038</b>	<b>7.1 %</b>	<b>579,844</b>	<b>5 %</b>	<b>11.46</b>	<b>8 %</b>	<b>0.38</b>	<b>10.3 %</b>
<b>1987 - 1990</b>	<b>16,476</b>	<b>9 %</b>	<b>591,977</b>	<b>5.1 %</b>	<b>12.6</b>	<b>8.8 %</b>	<b>0.45</b>	<b>12.2 %</b>
<b>Pre - 1987</b>	<b>14,202</b>	<b>7.8 %</b>	<b>316,695</b>	<b>2.7 %</b>	<b>7.88</b>	<b>5.5 %</b>	<b>0.32</b>	<b>8.7 %</b>